

TOPIC B – PART 5

MICRO/MACRO

NUTRIENTS

IB Chemistry
Topic B – Biochem



B5 Micronutrients and macronutrients - 2 hours

- B.5.1 Outline the difference between micronutrients and macronutrients. (2)
- B.5.2 Compare the structures of retinol (vitamin A), calciferol (vitamin D) and ascorbic acid (vitamin C). (3)
- B.5.3 Deduce whether a vitamin is water- or fat-soluble from its structure. (3)
- B.5.4 Discuss the causes and effects of nutrient deficiencies in different countries and suggest solutions. (3)



B5.1 – Micro vs Macro Nutrients

- *B.5.1 Outline the difference between micronutrients and macronutrients.*
- A **nutrient** is a substance required by an organism and needed for **metabolism** – the chemical reactions that occur inside cells.
- Nutrients include
 - Carbohydrates
 - Lipids
 - Proteins
 - Vitamins
 - Minerals and Water



B5.1 - Minerals

- A selection of **minerals** essential to human health are shown in the following slides. Plants and animals lacking an essential mineral will develop a characteristic deficiency disease or disorder
- Minerals have four functions in the body
 - They act as raw materials for the formation of body tissues
 - They provide the necessary chemical environment for cells
 - They act as metabolic intermediates for cell processes
 - They act as co-enzymes



B5.1 – Macronutrients

- The minerals in the first two categories are required in large amounts and are known as **macronutrients**
- The quantities required will be in excess of 0.005% of body mass. (for a 75kg male > 375 g)
 - They act as raw materials for the formation of body tissues
 - They provide the necessary chemical environment for cells



B5.1 – Macronutrient Table



Mineral	Major food source	Function
Calcium	Milk (Figure 22.63), cheese, bread	Bone and teeth formation; muscle contraction, nerve action, blood clotting and blood formation
Phosphorus	Cheese, eggs	Bone and tooth formation, respiration, ATP and nucleic acid formation
Sulfur	Dairy products, meat, eggs and broccoli	Formation of keratin and extracellular matrix; thiamin (vitamin B1) and co-enzymes
Potassium	Potatoes, meat and chocolate	Muscle contraction, nerve action and active transport across cell membranes
Magnesium	Meat and green vegetables	Formation of bones and co-enzymes for respiration
Chlorine	Salted foods, e.g. crisps and sea food	Maintaining the anion/cation balance in cells; formation of gastric juice (hydrochloric acid)
Sodium	Any salted food, meat, eggs and milk	Muscle contraction, nerve action and active transport across cell membranes

Table 22.3 Macronutrient minerals

B5.1 - Micronutrients

- Minerals in the last two categories are required in much smaller amounts and are known as **micronutrients**.
- They are required in miligram or microgram quantities ($10^3 \text{ mg} = 1\text{g}$; $10^6 \mu\text{g} = 1\text{g}$)
 - They act as metabolic intermediates for cell processes
 - They act as co-enzymes



B5.2 – Micronutrient Table

Mineral	Major food source	Function
Iron	Liver and red meat; some vegetables, e.g. spinach	Heme group in hemoglobin (oxygen carrier in blood)
Copper	Most foods	Cytochrome c oxidase (electron transport chain) (Section 22.9)
Fluorine	Milk, drinking water in some areas	Component of tooth enamel and bone.
Zinc	Most foods	Co-factor for enzymes
Iodine	Seafood and iodized salt	Thyroxine synthesis (control of basal metabolic rate)
Selenium	Plants, seafood, meat and mushrooms.	Antioxidants; reduces risk of cancer, heart disease; immune system
Manganese	Vegetables and most other foods.	Phosphatase enzymes (transfer phosphate groups)
Molybdenum	Most foods	Enzyme co-factor
Chromium	Most foods	Uptake of glucose
Cobalt	Most foods	Synthesis of vitamin B ₁₂ ; red blood cell development
Boron	Fruits and vegetables	Bones and brain function

Table 22.4 Micronutrient minerals

B5.2/3 – Vitamins A, C, D

- *B.5.2 **Compare** the structures of retinol (vitamin A), calciferol (vitamin D) and ascorbic acid (vitamin C). (3)*
- B.5.3 Deduce whether a vitamin is water- or fat-soluble from its structure. (3)
- **Vitamins** are a group of complex organic compounds present in very small quantities in food and absorbed into the body during digestion.
- They have **no energy value**, but are **essential** for a healthy body and for maintaining metabolism



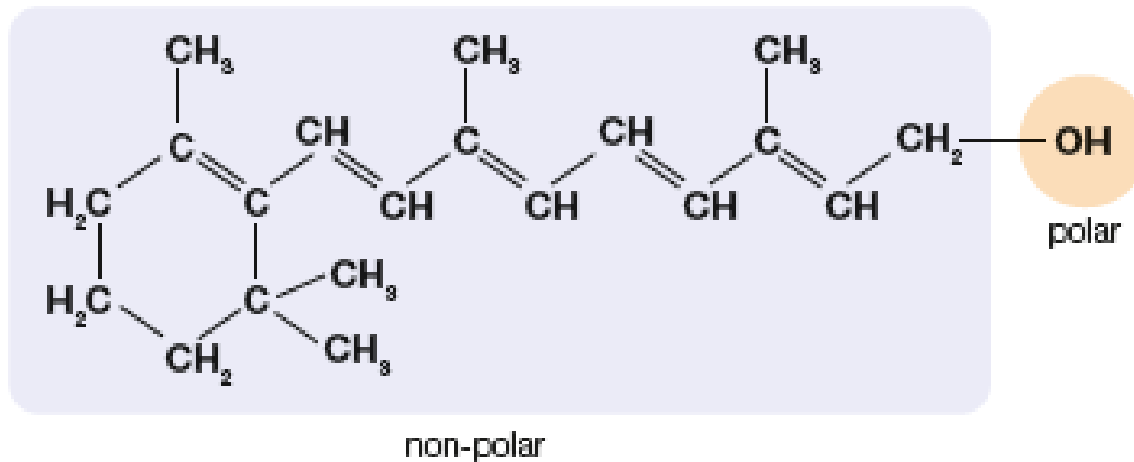
B5.2/3 – Vitamins A, C, D

- Vitamins are classified into two groups
 - Water-soluble (Vitamins C, B)
 - ◆ Only stored in small amounts inside cells
 - ◆ Must be supplied regularly
 - Fat-soluble (Vitamins A, D, E, K)
 - ◆ Stored in the liver and adipose (fat) tissue
 - ◆ The body can hold on til needed



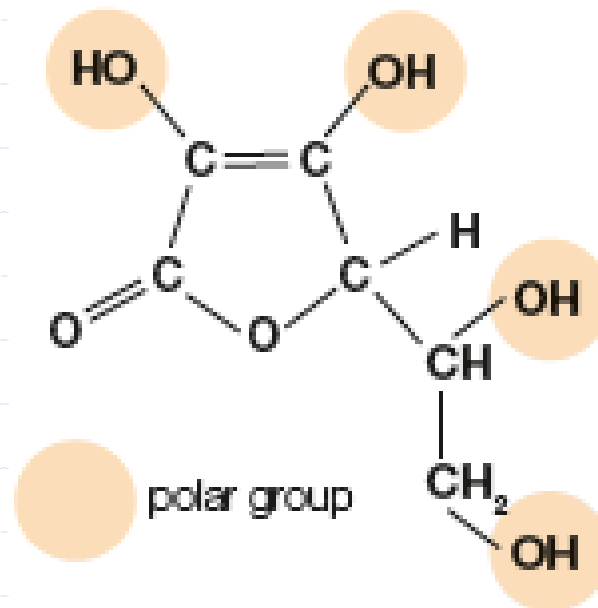
B5.3 – Vitamin A (retinol)

- The solubility of a vitamin can be deduced from its structure
- Consider vitamin A (retinol)
 - Polar hydroxyl group (-OH)
 - But is non-polar due to the presence of a large hydrocarbon 'skeleton.'
 - Is therefore fat-soluble and largely insoluble in water

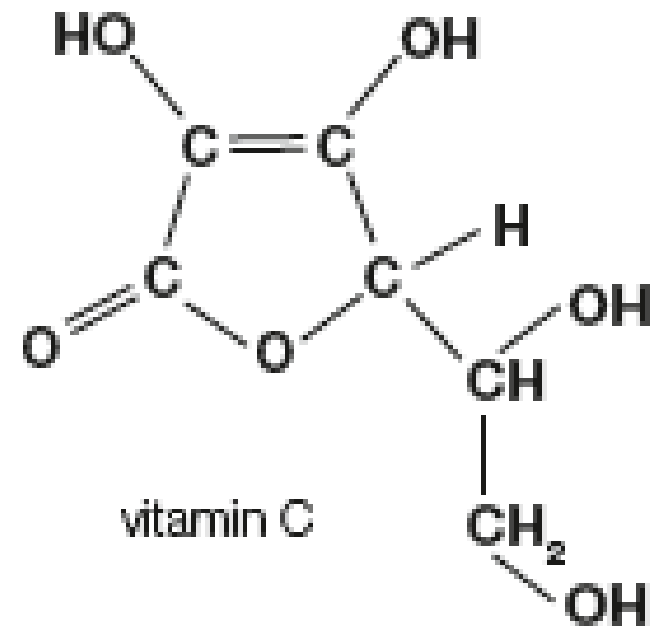
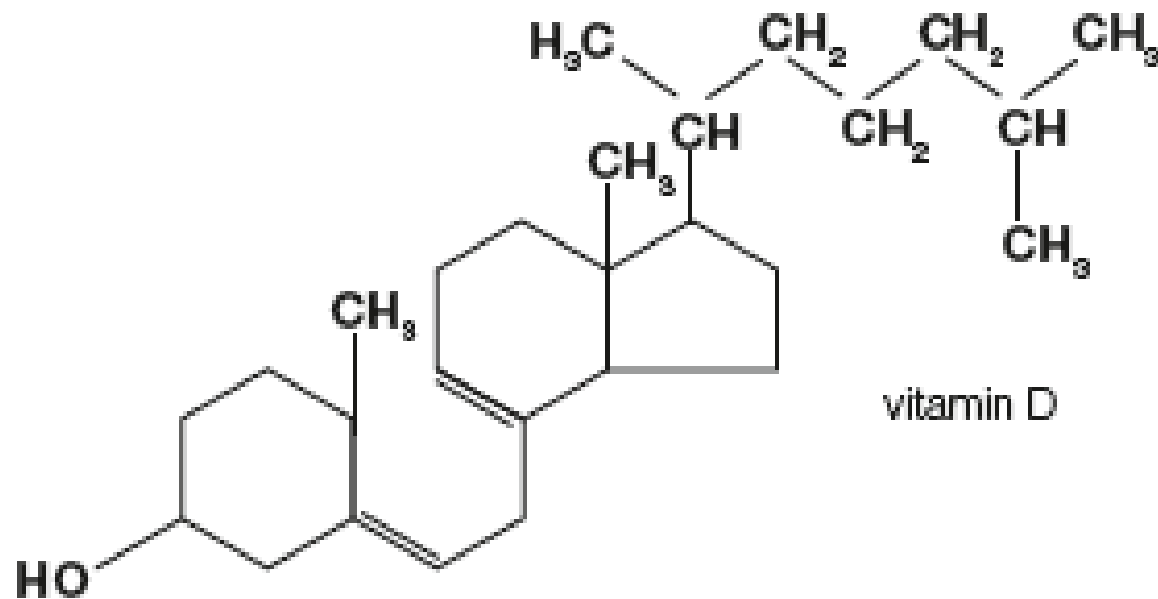
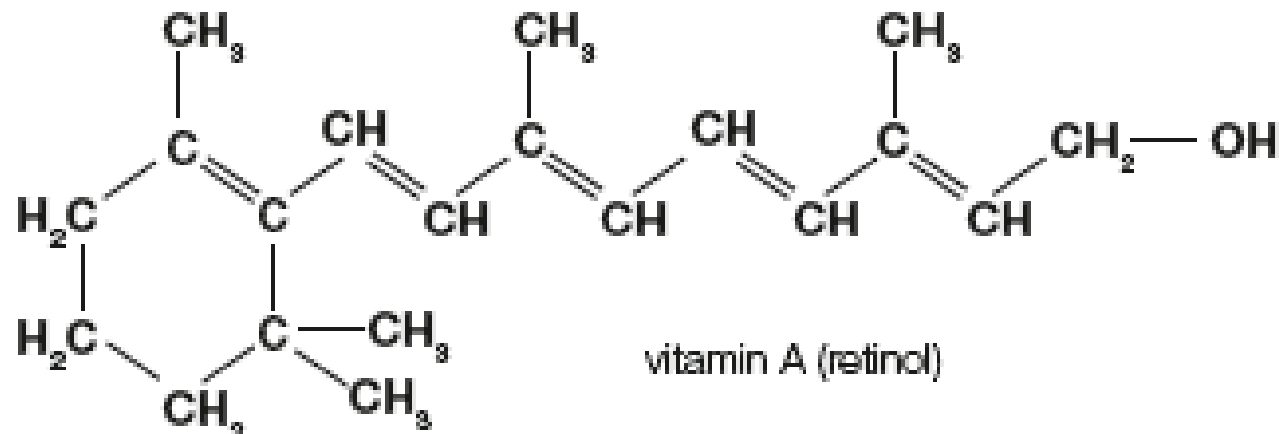


B5.3 – Vitamin C

- In contrast vitamin C is a much smaller molecule with a shorter hydrocarbon 'skeleton,' which contains four polar hydroxyl (-OH) groups that can all hydrogen bond
- Vitamin C is therefore expected to be polar in water



B5.3 – Structure of A, C, D



B5.4 – Nutrient Deficiencies

- *B.5.4 **Discuss** the causes and effects of nutrient deficiencies in different countries and suggest solutions. (3)*
- If the body does not contain enough of a vitamin a **disorder** occurs, which is termed a **deficiency disease**
- When intake is insufficient, the deficiency disease can be avoided by supplementing the diet with the necessary vitamin.



B5.4 – Vitamin Deficiencies

Name of vitamin	Important sources	Biological function	Deficiency disease
A (retinol)	Milk, butter, eggs, liver cod liver oil, green and yellow vegetables	The aldehyde form known as retinal is essential for the formation of the visual pigment rhodopsin	Skin and cornea in eye become dry (not connected with the function of retinal in rhodopsin); poor 'night vision'
D (calciferol)	Cod liver oil, eggs, margarine (if fortified), milk (if fortified); also synthesized by the body in the presence of sunlight	Controls calcium absorption; important in bone and tooth formation	Rickets in children: failure of bones to calcify and become hard. Osteomalacia in adults: spontaneous fractures
C (ascorbic acid)	Citrus fruits, green vegetables, potatoes, tomatoes	Essential for collagen synthesis	Scurvy – skin of gums becomes weak and bleeds; wounds fail to heal; connective tissue fibres fail to form
B ₁ (thiamin)	Unprocessed rice, whole cereals, egg yolk, liver, milk, green vegetables and fruits	Acts as a co-enzyme in aerobic respiration	Beri beri – nervous system affected; muscles become painful and weak; loss of appetite
B ₃ (niacin)	Meat, wholemeal bread, yeast extract and liver	Essential part of several co-enzymes	Pellagra – skin lesions, rashes and diarrhoea

Table 22.5 The sources, functions and deficiency diseases of the major human vitamins

B5.4 – Mineral Deficiencies

- Deficiency diseases also arise when a person's diet lacks a specific mineral.
- Minerals act as metabolites for
 - various cell processes
 - raw materials for body tissue formation, components of enzymes
 - providing the correct chemical environment for cells



B5.4 – Mineral Deficiencies



Mineral	Deficiency diseases caused	Symptoms of deficiency diseases
Calcium and phosphorus	Rickets in children and osteomalacia (softening of bones) in adults	Bones and teeth are affected; twisted limbs or unformed teeth
Sulfur		Skin problems or disorders, muscle pain, nerve disorders, circulatory trouble, stress, infection
Potassium	Rarely deficient	Heart disease
Chlorine		Muscular cramps
Sodium		Muscular cramps; heart disease
Iron	Anemia: low level of red blood cells	Fatigue, dizziness, rapid heart beat
Iodine	Goitre (Figure 22.67)	Enlarged thyroid gland and protruding eyes

Table 22.6 The sources, functions and deficiency diseases of the major minerals in the human diet



B5.4 - Deficiencies

- Some foods are '**fortified**' to ensure that a normal diet can provide sufficient vitamins or minerals to maintain health
 - For example, the milling of wheat removes part of the grain that's richest in vitamin B₁, so white flour has this vitamin added to it.
 - Margarine has vitamins A and D added
 - Vitamin C is often added to fruit juices and dehydrated mashed potatoes
 - Potassium iodide is commonly added to table salt



B5.4 - Deficiencies

- **Malnutrition** is a general term for a medical condition caused by improper or inadequate diets
- An extended period of malnutrition can result in:
 - Starvation
 - Vitamin or mineral deficiency diseases
 - Infection (since immune system is affected)



B5.4 – Iodine Deficiency

- Malnutrition caused by a lack of iodine in the diet results in a **goitre**
- Due to an over or under active thyroid
- Is relatively painless but can cause discomfort in movement as it enlarges

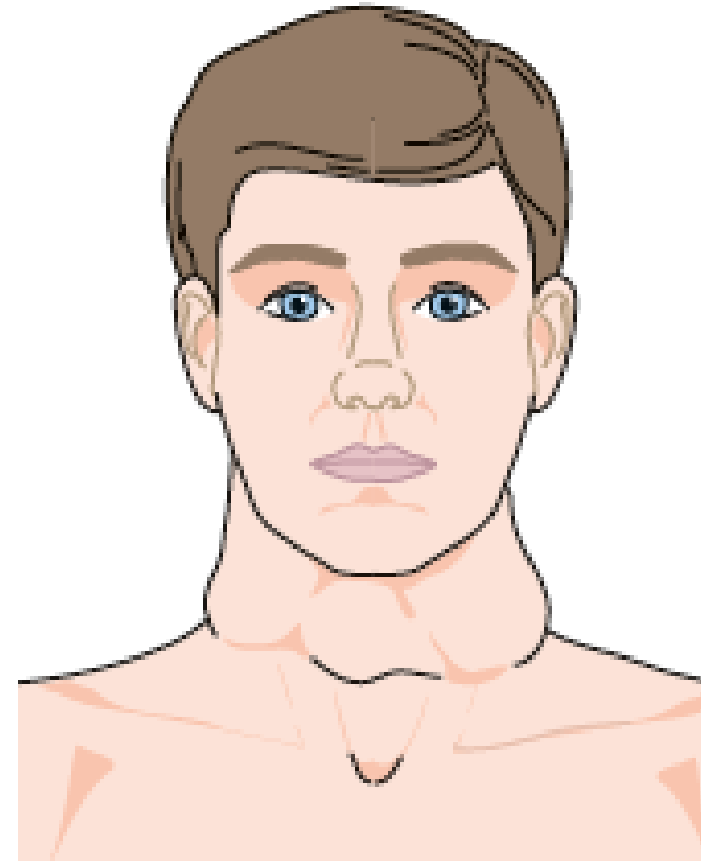


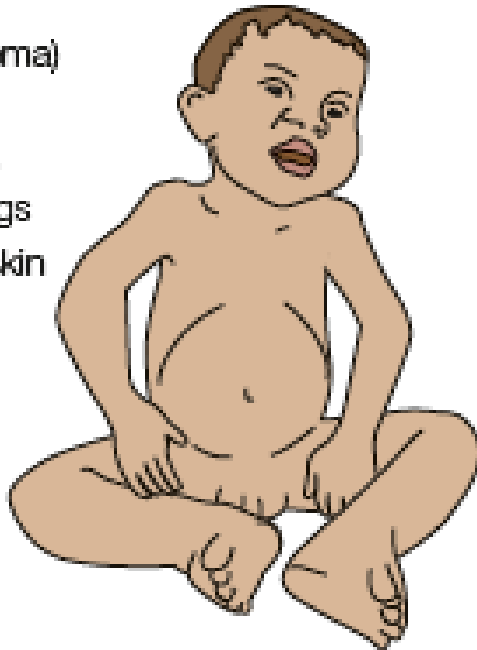
Figure 22.67 An adult untreated with goitre

B5.4 – Protein Deficiency

- Protein-energy malnutrition refers to a form of malnutrition where there is inadequate protein intake
 - Kwashiorkor
 - Marasmus

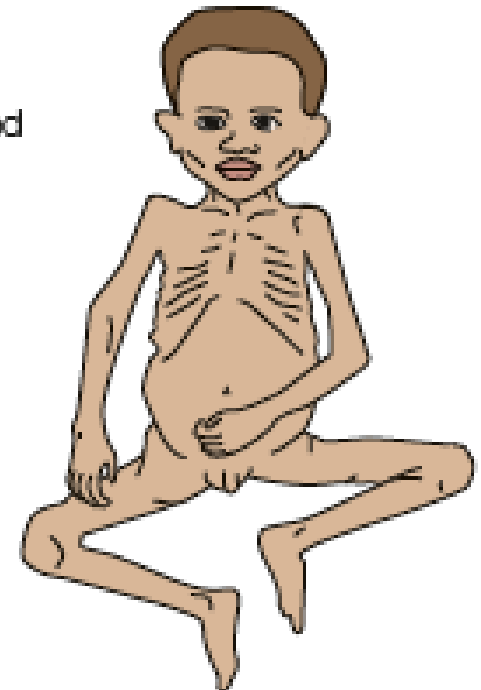
kwashiorkor

- swelling of legs (oedema)
- sparse hair
- 'moon face' with little interest in surroundings
- flaky appearance of skin
- swollen abdomen
- thin muscles, but fat present



marasmus

- normal hair
- 'old man' or wizened appearance
- thin limbs with little muscle or fat
- very underweight body



B5.4 – Marasmus (Protein Def)

- **Marasmus** is a form of severe protein malnutrition characterized by energy deficiency
- Leads to extensive tissue and muscle wasting and edema (accumulation of fluid beneath skin)
- Dry skin, loose skin folds
- Patients are often irritable and very hungry
- In children body mass is reduced to less than 80% of normal mass for that height



B5.4 – Kwashiorkor (Protein def)

- **Kwashiorkor** is a type of malnutrition commonly believed, in part, to be caused by insufficient protein consumption
- Children ages 1-4 affected although some adults
- Swollen abdomen (pot belly)
- Alternating bands of pale and dark hair
- Weight loss
- Dermatitis (inflammation of the skin) and depigmented skin



Likely due to deficiency of micronutrients (iron, folic acid, iodine, vit C, antioxidants)

B5.4 – Selenium Deficiencies

- Human **selenium deficiency** is rare in many countries but occurs in China where the soil concentration of selenium is low
- Also found in those that rely on intravenous drip in hospitals as their source of nutrition
- Gastrointestinal disorders may also decrease absorption of selenium, resulting in depletion
- Treated with supplements



B5.4 – Genetically Modified Plants

- Scientists claim that **genetically modified (GM)** plants can significantly reduce malnutrition, especially in the Third World, through the development of plants that are resistant to pest-derived disease, adverse soil pH or draught conditions.
- Plants can also be engineered to have a high level of specific nutrients
- Advantages of GM include: increased yield, reduction in harmful fertilizer use, reduction in machinery and labor costs, etc

